Energy artificial intelligence for effective energy imbalance cost reduction in the steel industry

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Summary

Renewable energy sources play a key role to achieve global CO_2 emission targets. However, the increasing penetration of solar and wind generation impacts short-term volatility and grid stability, ultimately resulting in higher imbalance penalties for large industrials. Such uncontrolled price fluctuations impose risks for steel plants with an electric arc furnace as the imbalance cost is a significant cost driver.

Alpiq and Swiss Steel established a convenient solution to reduce imbalance volume using artificial intelligence and real-time internet-of-things (IoT). The core of the method is a self-learning algorithm predicting the plant's power consumption for the next few hours based on real-time metering, day ahead forecast and further data. The forecast continuously predicts a 15-min profile which reflects latest available data, hence considering any deviations from the planned production schedule. The prediction is then applied as correction schedule and the differential volume placed as intraday re-nomination, unless overridden by Swiss Steel. We obtain a fully automated information flow with industrial IoT-gateways collecting data, a cloud-algorithm and automated communication between energy data management (EDM) systems.

With the new practice an imbalance volume reduction of up to 27% is achieved, effectively reducing cost and protecting against unpredictable imbalance prices. State-of-the-art technology enabled an attractive payback time. On top of the immediate benefit, the setup paves the way for future improvements, e.g. forecast horizon and performance. Furthermore, valuable process and performance insights beyond energy may be obtained in the future thanks to systematic real-time data availability and automated analytics.

Besides the cost saving advantage for the steel plant the concept also leads to better absorption of renewable energy in the market. This demonstrates how digital energy technology creates tangible value for power consumers while catalyzing the clean-energy transition. The best practice emphasizes the innovation spirit of the industry and increases its competitiveness.

Key Words

Energy artificial intelligence, real-time forecasting, IoT, intraday, imbalance cost reduction, electric arc furnace, Alpiq Digital, Swiss Steel, digital energy.

Introduction

The new renewable energy sources wind and solar photovoltaic (PV) and a rapidly growing number of electric vehicles play a key role to achieve global CO_2 emission targets. However, the increasing penetration of intermittent generation and electric vehicles leads to higher short-term volatility and reduced stability in the power grids. This drives the cost for grid balancing actions undertaken by transmission and distribution grid operators, which ultimately results in higher and more volatile imbalance cost for grid users as the cost for the balancing actions are forwarded to the electricity consumers.

The imbalance cost are calculated by the difference between *scheduled* (i.e. forecasted) and *actual* power consumption within each 15-min interval, in Switzerland Swissgrid sets and charges the balancing energy cost [1]. For steel plants with an electric arc furnace a precise power consumption forecast in 15-min resolution is particularly difficult for time-windows of several hours to day ahead as the exact furnace power-on time cannot be planned precisely. Therefore, typically, an average consumption profile is nominated day ahead. However, in this operational mode both imbalance energy volume and imbalance prices are high, volatile and not under full control by the steel plant and hence pose a significant cost driver and risk from the power supply.

Imbalance cost reduction possibility through intraday re-nomination scheme

One method to reduce the imbalance cost exposure is to reduce the effective imbalance volume. This can be achieved by re-nominating an updated power schedule closer to the time of consumption through intraday markets, a possibility that is widely available in Switzerland and Germany (and many other liberalized power markets) through power exchanges or bilateral agreements. Besides this contractual enabler the main pre-conditions to reduce overall

balancing cost through the intraday re-nomination scheme is an automated, robust short-term forecasting solution to update the predicted power consumption with minimum operational effort and impact on the production process.

Overview Energy artificial intelligence (AI) real-time forecasting solution

Alpiq and Swiss Steel found a convenient solution to use above described imbalance cost reduction scheme by using cloud-based artificial intelligence and real-time IoT. The solution incorporates the following elements, graphically illustrated in Fig. 1:

- Industrial IoT for real-time data processing;
- Cloud-computed forecasting algorithm;
- Automated intraday re-nomination.

We obtain a fully automated information flow with industrial IoT-gateways collecting data, a cloud-algorithm and automated communication between EDM-systems.

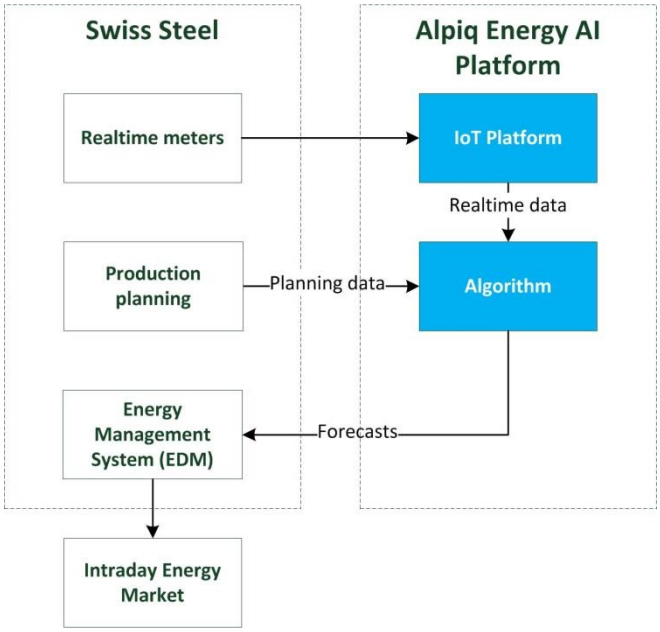


Figure 1: Illustration of the technical setup for the Energy AI real-time forecasting.

The individual elements are described briefly in the following sections.

Industrial IoT for data processing

The process starts with collecting the data required to calculate the consumption forecast. An industrial IoT device ("Asset Management Gateway") is directly connected to multiple energy meters on-site and continuously collects real-time meter data from the relevant loads (mainly from the arc furnace) and imports the up-to-date production schedule for the next days from the EDM system. The data is aggregated on Alpiq's Energy AI platform deployed in Amazon Web Services (AWS) cloud-infrastructure. The remote communication is handled by the Message Queuing Telemetry Transport (MQTT) protocol via internet and protected by state-of-the-art encryption software.

Real-time forecasting algorithm

The core of the solution is a purely data-driven algorithm based on supervised machine learning. Two years of historical high resolution consumption and planned production schedule data is used to train a recurrent neural network. The architecture of the network is based on Long-Short-Term-Memory [2] nodes. This choice was driven by their capability to capture sequential correlations. The output of the model is the forecast profile of the 15-min aggregated consumption load with a horizon of 2h.

Real-time data from five individual metering points are pre-analyzed and fed into the calibrated model together with the corresponding latest planned production schedule in the desired horizon of the forecast.

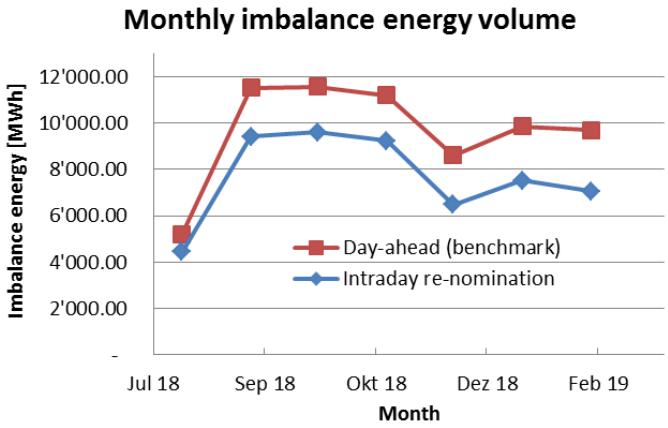
Automated intraday re-nomination

The forecast algorithm is executed every 15 min, and the output prediction used as correction schedule on the originally nominated consumption.

The result from the forecasting algorithm is communicated back Swiss Steel's EDM via a Secure File Transfer Protocol (SFTP) connection. From there the differential schedule is forwarded by Swiss Steel to the market partner, i.e. additional power is purchased in case consumption was underestimated or sold back in case it was overestimated, respectively. The nomination process can be overridden by Swiss Steel.

Results

The performance of the Energy AI forecasting algorithm is best measured as: *[monthly imbalance energy with intraday re-nomination]* compared to *[monthly imbalance energy volume without intraday re-nomination]*. Fig. 2(a) shows the absolute monthly imbalance energy without (red squares) and with (blue diamonds) the intraday correction nominations. The relative reduction of imbalance energy in % is shown in Fig. 2(b). We achieve an up to 27% reduction during the month of February 2019.



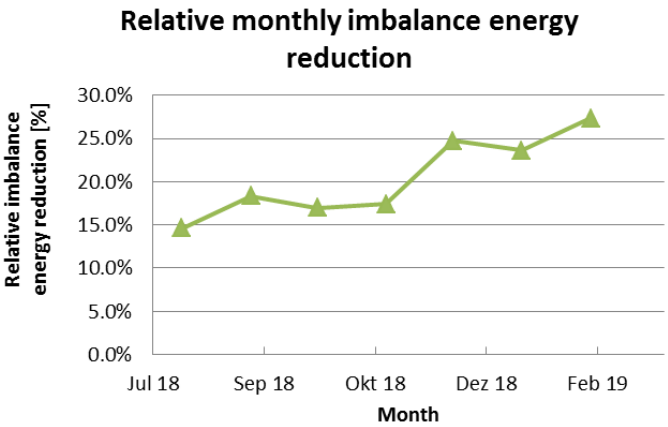


Figure 2: (a) Cumulated monthly imbalance energy volume without (red) and with (blue) intraday re-nominations. (b) Relative reduction of the monthly imbalance energy achieved through the Energy AI forecasting algorithm.

The performance increase from below 20% until Nov. 2018 to above 20% as of Dec. 2018 was achieved with a re-training of the algorithm using the accumulated data and results from the initial period. By considering additional process data and sensors, planning parameters or optimized nomination behavior we anticipate to be able to further improve the volume reduction in the near future.

Conclusion

With the new practice we achieve a monthly imbalance volume reduction of up to 27%, effectively reducing the imbalance cost for Swiss Steel on a monthly averaged basis, i.e. the intraday re-nomination actions result in lower imbalance cost than what would be charged through the imbalance mechanism without re-nomination. Besides the direct cost reduction the practice proportionally reduces the risk of being exposed to unpredictable imbalance price spikes. The state-of-the-art IoT and cloud technology enabled an attractive payback time for the new solution for both Swiss Steel and Alpiq.

On top of the immediate benefit, the setup paves the way for future improvements such as a longer forecast horizon and further increasing performance. As both algorithm and connected data streams are modular, additional input data can be included in the algorithm which potentially results in additional forecasting benefits. Furthermore, valuable process and performance insights beyond energy may be obtained in the future thanks to systematic real-time data availability and automated analytics.

Beyond the individual cost saving advantage for Swiss Steel the concept also leads to better absorption of intermittent renewable energy and loads in the market: our solution helps suppliers to better anticipate short-term energy flows and dispatch available flexible assets, e.g. hydro storage or decentral assets such as combined heat and power plants or batteries. This demonstrates how digital energy technology creates tangible value for power consumers while catalyzing the clean-energy transition by enabling the absorption of more renewable energy. The best practice emphasizes the innovation spirit of the steel and energy industry and increases their overall competitiveness.

Abbreviations

IoT	Internet-of-things
EDM	Energy data management
PV	Photovoltaic
AI	Artificial intelligence
AWS	Amazon Web Services
MQTT	Message queuing telemetry transport
SFTP	Secure file transfer protocol

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Acknowledgments

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